Northeast Regional Operational Workshop (NROW) XXIII
November 2–3, 2022 | Albany, New York

<u>Sponsored by</u>:

National Weather Service
University at Albany–SUNY
Department of Atmospheric and Environmental Sciences
American Meteorological Society

Agenda
Northeast Regional Operational Workshop XXIII
Albany, New York
UAlbany ETEC Building First Floor Shared Training Room
Day 1: Wednesday, November 2, 2022

8:00–8:30 am
Welcome/Registration
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

8:30–8:40 am
Opening Remarks & Conference Logistics
Christopher Gitro, Meteorologist-in-Charge
Daniel B. Thompson, NROW XXIII Steering Committee Chair
NOAA/NWS/WFO Albany, New York

8:40–8:55 am
Student Map Discussion
Erik Creighton
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

Session A – IDSS/Messaging I (8:55–9:55 am)

Session Chair: Neil Stuart, NOAA/NWS/WFO Albany, New York

8:55–9:15 am
Analyzing Extreme Temperature Variables Across the New York City Metropolis Using a Dense Network of in situ Observations
Nick Bassill
Center of Excellence
University at Albany, State University of New York

9:15–9:35 am
Communicating about Extreme Heat: Results from Card Sorting and Think Aloud Interviews with Experts and Non-Experts
Jeannette Sutton and Sav Olivas
College of Emergency Preparedness, Homeland Security and Cybersecurity
Department of Emergency Management and Homeland Security
University at Albany, State University of New York

9:35–9:55 am
Information Seeking, Sharing, and Processing among Atlantic Canadians during Hurricane Fiona
Amber Silver

College of Emergency Preparedness, Homeland Security and Cybersecurity
Department of Emergency Management and Homeland Security
University at Albany, State University of New York

9:55–10:15 am
Break
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

NROW XXIII Keynote Presentation (10:15–10:50 am)

Introduction
Stephen N. DiRienzo, Warning Coordination Meteorologist
NOAA/NWS/WFO Albany, New York

Keynote Presentation + Q&A
Commissioner Jackie Bray
New York State Division of Homeland Security and Emergency Services

10:50–11:00 am
Break
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

Session B – IDSS/Messaging II (11:00 am–12:00 pm)

Session Chair: Christina Speciale, NOAA/NWS/WFO Albany, New York
[V] = Virtual Presentation

11:00–11:20 am
Communicating Rip Current Risk in English and Spanish [V]
Jase Bernhardt
Hofstra University, Hempstead, New York

11:20–11:40 am
How the Smog Stole Christmas [V]
Myranda Fullerton
NOAA/NWS/WFO Pittsburgh, PA

11:40 am–12:00 pm
Plowing Through: Nationally Collaborated Snow Squall Forecast Saves Lives
Bryan A. Jackson
NOAA/NWS Weather Prediction Center, College Park, Maryland

Lunch/Optional ETEC Tour (12:00–2:00 pm)

Refer to Restaurant Guide at weather.gov/aly/nrow23 for area restaurants

<u>Session C – Severe Weather I</u> (2:00–3:00 pm)

Session Chair: Joseph P. Villani, NOAA/NWS/WFO Albany, New York

2:00–2:20 pm
A Local Verification Study of Convection-Allowing Model Performance during Convective Events in Eastern New York and Western New England
Part I: Initial findings
Michael Evans
NOAA/NWS/WFO Albany, New York

2:20–2:40 pm
A Local Verification Study of Convection-Allowing Model Performance during Convective Events in Eastern New York and Western New England
Part II: Environmental Breakdown
Michael Main
NOAA/NWS/WFO Albany, New York

2:40–3:00 pm
Evaluating HRRR Model Forecasts of Impactful Severe Weather Events in Upstate New York
Rachel A. Eldridge
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

3:00–3:20 pm
Break
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

<u>Session D – Model Evaluation</u> (3:20–4:40 pm)

Session Chair: Kevin Lipton, NOAA/NWS/WFO Albany, New York

3:20–3:40 pm
Numerical Weather Prediction at Urban Scales: Operational forecasting overview of uWRF over New York Metropolitan region
Jorge E. González-Cruz
Atmospheric Science Research Center
University at Albany, State University of New York

3:40–4:00 pm
Evaluating and Improving Snow Prediction in the National Water Model in New York State using New York State Mesonet Data
Sierra Liotta
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

4:00–4:20 pm
Displacement Error Characteristics of 500-hPa Cutoff Lows in Operational GFS Forecasts
Kevin M. Lupo
National Center for Atmospheric Research, Boulder, Colorado

4:20–4:40 pm
GAZPACHO Version 6: A Summary of New Features and Enhancements
Joseph P. Villani
NOAA/NWS/WFO Albany, New York

4:40–4:50 pm
Closing Remarks/Adjourn
Daniel B. Thompson, NROW XXIII Steering Committee Chair
NOAA/NWS/WFO Albany, New York

Agenda
Northeast Regional Operational Workshop XXIII
Albany, New York
UAlbany ETEC Building First Floor Shared Training Room
Day 2: Thursday, November 3, 2022

7:30–8:00 am
Welcome/Registration
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

8:00–8:05 am
Opening Remarks
Christopher Gitro, Meteorologist-in-Charge
Daniel B. Thompson, NROW XXIII Steering Committee Chair
NOAA/NWS/WFO Albany, New York

<u>Session E – Novel Products and Techniques for Operations</u> (8:05–9:25 am)

Session Chair: Brian Frugis, NOAA/NWS/WFO Albany, New York
[V] = Virtual Presentation

8:05–8:25 am
Improvement in NOAA Winter Weather Operations using New York State Mesonet Observations
Junhong (June) Wang
New York State Mesonet
University at Albany, State University of New York

8:25–8:45 am
Data Fusion: A Machine Learning Tool for Forecasting Winter Mixed Precipitation Events
Brian Filipiak
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

8:45–9:05 am
Update on Research to Operations Activities: Some Successes and New Challenges
Brian A. Colle
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

9:05–9:25 am
Using Machine Learning Clustering Algorithms to Identify Synoptic Environments Conducive to Flood/Flash Flood Conditions in the NWS Boston (BOX) County Warning Area [V]
Rob Megnia

NOAA/NWS/WFO Boston/Norton, Massachusetts

<u>Poster Session – ETEC First Floor Lobby</u> (9:25–10:10 am)

Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

Analysis of the 15 May 2018 Severe Weather Event in Eastern New York
Erik Creighton
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

Precipitation Type in the High-Resolution Ensemble Forecast System during the February 17th & February 23rd, 2022 Winter Storms
John R. England
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

Validation of Offshore Winds in the ERA5 Reanalysis Using Two Floating LIDARS South of Long Island
Christopher G. Fragano
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

Analysis of the 14 December 2018 Severe Weather Observed During RELAMPAGO
Emily Lucy
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

<u>Session F – Severe Weather II</u> (10:10–11:30 am)

Session Chair: Thomas A. Wasula, NOAA/NWS/WFO Albany, New York
[V] = Virtual Presentation

10:10–10:30 am
September 5, 2022 Flash Flooding in Providence, RI [V]
Joseph W. DelliCarpini
NOAA/NWS/WFO Boston/Norton, Massachusetts

10:30–10:50 am
Using MRMS Rotational Tracks for Northeastern US Tornado Warning Guidance
Brian J. Frugis
NOAA/NWS/WFO Albany, New York

10:50–11:10 am
Improvement of Tornado Detection and Lead Time: Update of Environmental and Radar Parameters for the WFO Boston/Norton County Warning Area [V]

Joseph W. DelliCarpini
NOAA/NWS/WFO Boston/Norton, Massachusetts

11:10–11:30 am
November 13, 2021 Southern New England Tornado Outbreak
Hayden Frank
NOAA/NWS/WFO Boston/Norton, Massachusetts

<u>Lunch</u> (11:30 am–1:00 pm)

Refer to [Restaurant Guide]() at weather.gov/aly/nrow23 for area restaurants

<u>Session G – Winter Case Studies</u> (1:00–2:20 pm)

Session Chair: Andrei Evbuoma, NOAA/NWS/WFO Albany, New York
[V] = Virtual Presentation

1:00–1:20 pm
The January 28-29, 2022 Mid Atlantic Blizzard [V]
Paul Fitzsimmons
NOAA/NWS/WFO Philadelphia/Mount Holly, New Jersey

1:20–1:40 pm
Forecast and Impact-Based Decision Support Services During the January 28-29, 2022 Blizzard in Southern New England
Hayden Frank
NOAA/NWS/WFO Boston/Norton, Massachusetts

1:40–2:00 pm
The Heavy Mixed Precipitation and Localized Ice Storm on 3-4 February 2022 in Eastern New York
Part I: Synoptic and Mesoscale Overview
Thomas A. Wasula
NOAA/NWS/WFO Albany, New York

2:00–2:20 pm
The Heavy Mixed Precipitation and Localized Ice Storm on 3-4 February 2022 in Eastern New York
Part II: Warnings, Communication of Hazards and Verification
Christina Speciale
NOAA/NWS/WFO Albany, New York

2:20–2:40 pm
Break
Refreshments Sold by UAlbany AMS Chapter – ETEC First Floor Lobby

<u>Session H – Winter Field Campaigns</u> (2:40–4:20 pm)

Session Chair: Michael Main, NOAA/NWS/WFO Albany, New York
[V] = Virtual Presentation

2:40–3:00 pm
Identification of Cool Season Precipitation Structures Within the Cyclone Comma Head during the IMPACTS Field Campaign
Phillip Yeh
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

3:00–3:20 pm
Multifrequency Radar Observations of Precipitation and Turbulent Structures within East Coast Winter Storms
Erin Leghart
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

3:20–3:40 pm
The Winter Precipitation Type Multiscale Experiment (WINTRE-MIX): Overview and Initial Results
Justin R. Minder
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

3:40–4:00 pm
Investigating the Difference Between Members in the High-Resolution Rapid Refresh Ensemble (HRRRE) during the 23 February 2022 Winter Storm
Michael Barletta
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

4:00–4:20 pm
Modeling Surface Precipitation Type Transition from Freezing Rain to Ice Pellets: A WINTRE-MIX Case Study [V]
Bin Han
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York

4:20–4:30 pm
Closing Remarks/Adjourn
Daniel B. Thompson, NROW XXIII Steering Committee Chair
NOAA/NWS/WFO Albany, New York

Analyzing Extreme Temperature Variables Across the New York City Metropolis Using a Dense Network of in situ Observations

Nick Bassill
Center of Excellence
University at Albany, State University of New York

Although many people may immediately think of hurricanes or blizzards when they imagine deadly weather events, the reality is that heatwaves are typically more deadly on an annual basis. While heatwaves most commonly develop due to synoptic-scale factors, they are modulated on a local scale by proximity to land use characteristics, water bodies, and other influences. While New York City (NYC) is geographically quite small, all of these factors can create disparate impacts in each of the five boroughs, or even within them. NYC has a wealth of high-quality observational networks including the NYS Mesonet, the Con Edison micronet (operated by the NYS Mesonet), standard ASOS sites, and more. These roughly 30 sites in or near NYC allow for a more detailed look at the distribution of temperature across NYC during extreme heat events.

This presentation will examine heat in NYC and introduce a NOAA-funded project designed to examine extreme temperatures in NYC using these observational datasets, including some of the challenges inherent to measuring extreme temperatures in an urban environment. A particular focus will be applied to Wet-bulb Globe Temperature (WBGT), which is a complex variable incorporating temperature, moisture, sunshine, and wind speed with the goal of providing added value beyond commonly used metrics such as heat index. WBGT is a tool that NWS believes is underutilized, but which is gaining increased use.

This work is supported by NOAA award NA21OAR4590360.

Communicating about Extreme Heat: Results from Card Sorting and Think Aloud Interviews with Experts and Non-Experts

Jeannette Sutton and Sav Olivas
College of Emergency Preparedness, Homeland Security and Cybersecurity,
Department of Emergency Management and Homeland Security,
University at Albany, State University of New York

Climate trends indicate that extreme heat events are becoming more common and more severe over time, requiring improved strategies to communicate heat risk and protective actions. However, there exists a disconnect in heat-related communication from experts, who commonly include heat related jargon (i.e., technical language), to non-experts, including the general public and emergency mangers. The use of jargon has been shown to reduce meaningful engagement with and understanding of messages written by experts. Translating technical language into comprehensible messages that encourage decision makers to take action has been identified as a priority to enable impact-based decision support. Knowing what concepts and terms are perceived as jargon, and why, is a first step to increasing communication effectiveness. With this in mind, we focus on the mental models about extreme heat among two groups of people – experts (those trained in atmospheric science) and non-experts (those trained in emergency management) to identify how each group understands terms and concepts about extreme heat. We use a hybrid data collection method of open card sorting and think-aloud interviews to identify how participants conceptualize and categorize terms and concepts related to extreme heat. While we find few differences within the sorted categories, we learn that the processes leading to decisions about the importance of including, or not including, technical information differs by group. The results lead to recommendations and priorities for communicating about extreme heat.

Information Seeking, Sharing, and Processing during Hurricane Fiona

Amber Silver[1], Brandon Behlendorf[1], Joel Finnis[2], and Jennifer Spinney[3]
[1]College of Emergency Preparedness, Homeland Security and Cybersecurity,
Department of Emergency Management and Homeland Security,
University at Albany, State University of New York
[2]Department of Geography, Memorial University of Newfoundland, St. John's, Newfoundland
[3]Department of Disaster & Emergency Management, York University

Hurricane Fiona was forecasted to be the strongest land-falling hurricane in Canadian history. Given the size of the storm, it was anticipated that Fiona would cause differential impacts across the Atlantic region--in other words, it was anticipated that the storm would cause significant damage in some areas (e.g., eastern Nova Scotia, western Newfoundland) and minimal damage in others. Residents had to seek, assess, and share multiple sources of official and unofficial information in order to best prepare themselves and others. This study utilized a questionnaire instrument disseminated two weeks after Fiona's landfall to the three hardest hit provinces: Nova Scotia, Prince Edward Island, and Newfoundland. The preliminary results suggest that Atlantic Canadians generally felt the storm was well forecasted and its impacts were well predicted. Respondents indicated that they were able to access the information they needed to make good decisions despite wide-spread power outages, with local television/radio, social media, and word-of-mouth being widely relied upon for information. Interestingly, the Environment and Climate Change Canada website and the Canadian Hurricane Center website were less relied upon during this storm. The findings of this research will be shared in the context of how to effectively communicate with end-users during severe and hazardous weather.

Communicating Rip Current Risk in English and Spanish

Jase Bernhardt
Hofstra University, Hempstead, New York

Rip currents are a leading cause of weather-related fatalities in the United States but are poorly understood by the public. Individuals who speak languages other than English, such as Spanish-speaking communities, have been historically underserved by National Weather Service (NWS) risk communication efforts for natural hazards and thus are at additional risk from rip currents. In response to that issue, the NWS recently released rip current informational brochures translated into Spanish. However, their efficacy has not been tested. Thus, we surveyed members of the Spanish-speaking community in Nassau and Queens Counties, New York during July and August of 2022 to gain insights into how the brochures are working and possible improvements to be made. Preliminary analysis of the survey results indicate that while the Spanish-language brochure is somewhat effective, several changes could be made to improve clarity and relatability. For example, the translation of the term Rip Current itself used by the NWS was found to be confusing by Spanish speakers of certain ages and dialects. Moreover, some of the graphics contained in the brochure were difficult to understand for users with limited knowledge of beach hazards. The results of this work can be used directly by the NWS and other agencies to improve their Spanish-language risk communication tools, and also as a guide when translating hazard information into other languages.

How the Smog Stole Christmas

Myranda Fullerton
NOAA/NWS/WFO Pittsburgh, Pennsylvania

Air quality concerns have been a longstanding part of Pittsburgh's industrial history dating back to the rise and fall of the steel industry. Despite the technological 'renaissance' that has re-energized the city in recent years, with advancements in producing and monitoring cleaner emissions and efforts to increase public awareness to the impacts of pollution, there are still days with poor air quality. These days are usually accompanied by a particular set of meteorological conditions. Over the last ten years, some locations within the Greater Pittsburgh metro area observed close to 400 days where air quality was deemed "unhealthy." Given the frequency of days with poor air quality, it is important for Pittsburgh's National Weather Service (NWS) forecasters to understand the relationship between meteorological variables and deterioration of air quality. From 21-26 December 2019, an unusually prolonged period of poor air quality was observed, during which the Air Quality Index was deemed "unhealthy for sensitive groups." For this six-day stretch, the United States Environmental Protection Agency (EPA) Air Quality System (AQS) data showed that pollutant concentration increased by nearly 486% in conjunction with a persistent low-level temperature inversion and the development of very dense fog. This was the first time that air quality reached this threshold for a prolonged period since July 2010. As a result of this episode, NWS Pittsburgh collaborated with county and state officials to streamline Air Quality Alert (AQA) messaging and communication, and to propose the creation of a meteorological toolset that can be used as a method of decision support to stakeholders. This presentation will provide analysis of inversion height and thickness during the six-day December 2019 episode and its relationship to the elevated pollutant concentrations, relate this event to previous historical air quality incidents, and discuss improved methods of Decision-Support Service with respect to air quality concerns.

Plowing Through: Nationally Collaborated Snow Squall Forecast Saves Lives

Bryan A. Jackson and Joshua Weiss
NOAA/NWS Weather Prediction Center

Nationally consistent, impact based, decision support messaging has become one of the primary goals for the National Weather Service (NWS) as the agency continues to evolve toward a Weather Ready Nation. This requires an increasingly collaborative paradigm, with the National Centers of Environmental Prediction (NCEP) serving as a foundation in this process by providing larger-scale expertise to regional and local forecast messaging provided by the Weather Forecast Offices (WFOs).

As part of this approach to enhanced collaboration, in 2018 the Weather Prediction Center (WPC) began creating, coordinating, and disseminating Key Messages for large scale winter storms which pose a significant threat for travel disruption and to life and property. The purpose of these Key Messages is to highlight the most essential information for upcoming winter storms and align hazard messaging across the NWS field structure.

For the 2021-2022 winter season, WPC expanded the scope of Key Messages criteria to include cases of larger scale snow squalls. Despite their relative rarity, and limited spatial and temporal scales, snow squalls can be highly disruptive and life-threatening. Consistent and accurate forecasts and messaging are crucial to effectively communicate any weather phenomenon, including snow squalls. In the case of February 18-19, 2022, WPC and multiple NWS WFOs successfully coordinated the first ever issuance of Key Messages for snow squalls. These were issued well in advance of the first snow squall warnings (SQW), which helped drive a coordinated local messaging and warning strategy from neighboring WFOs. The result of this collaboration potentially saved lives as motorists were alerted to potential life-threatening snow squalls through a high cadence of NWS messaging to core partners and the public, and the issuance of a record-setting 92 SQWs.

This presentation will highlight how successful use of the collaborative forecast process and WPC Key Messages can lead to improved accuracy and lead times for dangerous weather phenomena, even mesoscale phenomena such as snow squalls.

A Local Verification Study of Convection Allowing Model Performance during Convective Events in Eastern New York and Western New England Part I: Initial Findings

Michael Evans
NOAA/NWS/WFO Albany New York

Convection Allowing Models (CAMs) have become an increasingly utilized tool for forecasters to anticipate the development and evolution of convective weather during the past several years. Formal and informal evaluations of CAMs during convective weather events have been performed over the past several years at places ranging from testbeds, to universities, modeling centers and forecasting offices. This presentation describes a study recently completed at the National Weather Service Forecast Office in Albany NY (NWS ALY) on the performance of the 3 km NAM nest and HRRR models during convective events that occurred in eastern New York and western New England during the warm season of 2021. The study utilized subjective evaluations from forecasters with a wide range of experience levels, using a methodology similar to evaluations done at NOAA's Hazardous Weather Testbed. Participating forecaster's experience level in this project ranged from undergraduate students, to National Weather Service forecasters with over 20 years of experience.

The study evaluated CAM forecasts from 32 events that included at least one report of severe weather and/or one report of flash flooding in the NWS ALY county warning area (CWA) during the 2021 warm season (severe cases). In addition, 16 cases were evaluated when NOAA's Storm Prediction Center forecast at least a marginal potential for severe storms in the NWS Albany CWA, but no reports of severe weather occurred (null cases). For each case, forecasters evaluated CAM-forecasts of the magnitude of coverage of convection across the study area, timing of convection, and forecasts of convective mode (i.e. linear vs. discrete). Results from the study indicated that CAM-forecast coverage tended to be slightly underdone for severe cases, but substantially overdone for null cases. The 00 UTC HRRR model was most overdone with coverage during null events. Both the NAM nest and HRRR tended to be too slow with timing of convection during severe cases, and no timing bias was evident for null cases. Finally, the NAM nest and HRRR model forecasts appeared to be of similar quality regarding storm evolution during severe cases. There did appear to be a tendency for the HRRR model's forecasts of convective evolution to improve from the 00 UTC to the 12 UTC run times, while no such improvement was noted with the NAM nest.

A Local Verification Study of Convective Allowing Model Performance during Convective Events in eastern New York and western New England Part II: Environmental Breakdown

Michael Main and Michael Evans
NOAA/NWS/WFO Albany, New York

Use of Convective Allowing Models (CAMs) in an operational capacity has become increasingly popular over the last several years. Several studies have been conducted to analyze the performance of CAMs across a wide variety of spatial and temporal scales. This presentation is the second part of a two-part presentation describing a collaborative CAM evaluation study recently completed by staff at the Albany, New York National Weather Service (NWS ALY) office and students at the State University of New York (SUNY) at Albany. Part I of the study presented the results from subjective evaluations of CAM performance regarding the coverage, timing, and overall evolution of convection as depicted by both the High Resolution Rapid Refresh (HRRR) model and the 3 km North American Mesoscale (NAM) nest model. This Presentation concentrates on the relationship between model performance and characteristics of the convective environment across eastern New York and western New England.

Data from the Storm Prediction Center (SPC) mesoanalysis archive were used to determine the maximum mixed-layer convective available potential energy (MLCAPE) and 0–6 km bulk shear values during each of the 32 cases outlines in Part I that had a severe weather and / or flash flood report. Null events were not included in Part II of this study. Next, environments were classified according to the Sherburn et al. (2016) criteria as being either high shear high CAPE (HSHC), high shear low CAPE (HSLC), low shear high CAPE (LSHC), or low shear low CAPE (LSLC). The same forecaster evaluations from Part I were used to assess CAM performance in the aforementioned environments. Preliminary results show that the 3 km NAM depicted reasonable coverage for HSLC and HSHC events, but coverage was overdone for LSHC events. The HRRR showed a small high bias for HSLC events, but a large under-forecast error of convective coverage for both the LSHC and HSHC events. Both CAMs were too slow with the timing of convection in all environments, but the slow bias was most noticeable for LSHC environments, especially in the HRRR. Forecaster evaluations indicated that the overall forecast convective evolution was best simulated for HSLC events, followed by HSHC events. LSHC events received the lowest forecaster grades for both CAMs. An investigation of whether changing the CAPE/shear thresholds utilized impacted the results will also be presented.

Evaluating HRRR Model Forecasts of Impactful Severe Weather Events In Upstate New York

Rachel A. Eldridge, Brian H. Tang, Robert G. Fovell
Department of Atmospheric and Environmental Sciences,
University at Albany, State University of New York

Forecasting severe convection can be more challenging in areas of complex terrain, such as in and around the valleys and mountains of Upstate New York. Biases in numerical weather prediction models, related to the lack of resolution of the terrain and errors in physical parameterizations, can affect forecasts of convection. The main goal of this research is to assess biases in the High-Resolution Rapid Refresh (HRRR) pre-convective environment that could contribute to deficiencies in the forecasted convective evolution.

We investigate how the HRRR model performed during a few notable severe weather events that affected the New York Mohawk Valley and Capital Region. These events were characterized by their intense line of thunderstorms that resulted in numerous wind damage reports across the region. HRRR model output was compared to New York State Mesonet (NYSM) surface observations, NYSM profiler data, and NEXRAD reflectivity data for these events during the period they passed over the Mohawk and Hudson valleys. Moisture variables, wind, temperature, and turbulence were analyzed across multiple HRRR model runs. Preliminary results show discrepancies between the model forecast and surface observations in the hours leading up to the convection. The HRRR model forecasts tend to have a warm bias, especially in the early morning. Additionally, there is case-to-case variability in the forecasts of the dewpoint and convective evolution that are worth exploring. Further exploration of cases and HRRR biases will inform forecasters and may lead to better warnings in this populated and economically important region.

Numerical Weather Prediction at Urban Scales: Operational forecasting overview of uWRF over New York Metropolitan region

Prof. JE. González-Cruz[1], Harold Gamarro[2], Jhon Ibsen[2], Bob Bornstein[3]
[1]Atmospheric Science Research Center, University at Albany, State University of New York
[2]City College of New York, Mechanical Engineering Department, New York, New York
[3]San José State University, San José, California

Accurately forecasting high-impact weather events in urban environments is crucial due to the vast populations at high risk. To bridge the gaps between traditional mesoscale weather modeling and complex coastal urban areas, an operational forecasting system has been deployed over the New York City metropolitan region. The Weather Research and Forecasting (WRF) model, coupled with a multi-layer urban canopy and building energy model, is used to evaluate impacts of urbanization on New York's precipitation, temperatures, and winds inside the urban boundary layer in forecast mode. The urban canopy model considers the thermal impacts such as heat fluxes (latent and sensible) from roofs, streets, and walls, as well as the reflection and trapping of radiation in the street canyon. It also considers the mechanical effects on wind patterns from manmade complex structures. The building energy model on the other hand, accounts for the sensible and latent heat exchanges through the building envelope due to the use of air conditioning, cooling towers, and water accumulation on impervious surfaces. Various case studies have been performed for historical heat waves that affected the region, delving into the interaction of these extreme events and the urban surface with a focus on its impacts to temperatures and stability of the urban boundary layer. This operational system provides a daily 72-hour weather forecast at 1-km horizontal resolution that has been online since 2015, showcasing the latest in our group's urban weather prediction. A real time performance assessment tool is also employed to compare the forecast with selected ground and vertical sensors used to document the historical performance of the forecasts, demonstrating remarkable accuracy. This presentation will summarize model development and configuration, selected case studies, and model performance against observations.

Evaluating and Improving Snow Prediction in the National Water Model in New York State using New York State Mesonet Data

Sierra Liotta[1], Justin R. Minder[1], Patrick Naple[1], and Theodore W. Letcher[2]
[1]Department of Atmospheric and Environmental Sciences,
University at Albany, State University of New York
[2]Cold Regions Research and Engineering Laboratory

When snow melts, the water drains into nearby streams and rivers which can impact water supply and flood hazards. The National Water Model (NWM) provides high quality forecast data for streamflow in the continental United States using mathematical representations of hydrologic processes. This research evaluates how the NWM simulates snowpack in New York State. Within the NWM, Noah-MP is the land surface model (LSM) used to simulate processes on land such as snow melt. There can be biases in these simulations due to errors in the LSM formulation and/or meteorological input. To evaluate the representation of snow melt in Noah-MP, we run point simulations at the New York State Mesonet (NYSM) sites and force Noah-MP with NYSM meteorological observations. This isolates the biases associated with model parameterizations and allows us to manipulate the way the model handles various processes. Additionally, we run distributed runs across the whole state forced by a gridded meteorological analysis to compare to the point simulations at the NYSM sites. We also explore which parameters impact snowpack in Noah-MP the most by conducting controlled sensitivity experiments where aspects of the model are altered in isolation and to highlight areas where improvement is needed.

The NYSM observations were used to evaluate the representation of snowmelt events in Noah-MP in both point-simulations and distributed runs. This data includes measurements of snow depth, snow water equivalent (SWE, the depth of water produced if the snow was melted) and surface energy inputs/outputs (fluxes). When comparing distributed runs to the point-simulations and NYSM observations, it is revealed that the snow depth and SWE outputs are inconsistent between the two. Differences between the point simulations and distributed runs could be due to the differing vegetation classification (point-grassland vs. distributed-mostly forested). In a forested environment, the canopy impacts snowpack because trees can intercept snowfall and block radiation from reaching the ground.

Parameterizations in Noah-MP that have an impact on the snow accumulation and snow ablation period were identified and point simulations were run with alterations to these parameterizations. Altering the representation of precipitation phase in Noah-MP was shown to improve the snow accumulation when we use the HRRR based precipitation partitioning method in the model. Additionally, accelerating the rate in which the model ages snow improves the snow albedo and therefore the ablation period. The exact values that are best for these changes differ between the point simulations and distributed runs. To further investigate what causes these differences in the outputs, we use manual snow depth and SWE measurements taken in different vegetation zones near NYSM sites and evaluate radiation outputs from the distributed runs. When there are deviations in snow depth between the model and the observations, comparing deviations in the flux data can help us understand what is going wrong. We are using this analysis to optimize the most sensitive parameters in Noah-MP to reduce errors in the NWM predictions for the northeastern United States and improve streamflow forecasts for emergency and water resource management.

Displacement Error Characteristics of 500-hPa Cutoff Lows in Operational GFS Forecasts

Kevin M. Lupo, Craig Schwartz, and Glen Romine
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Cutoff lows are often associated with high-impact weather; therefore, it is critical that operational numerical weather prediction systems accurately represent the evolution of these features. However, medium-range forecasts of upper-level features using current and previous versions of the GFS are often subjectively characterized by excessive synoptic progressiveness, i.e., a tendency to advance troughs and cutoff lows too quickly downstream. To better understand synoptic progressiveness errors, this research quantifies seven years of 500-hPa trough and cutoff low position errors over the Northern Hemisphere, with the goal of objectively identifying regions where synoptic progressiveness errors are common and how frequently these errors occur. Specifically, 500-hPa features are identified and tracked in 6–240-hour 0.25° GFS forecasts during April 2015–March 2022 using an objective cutoff low and trough identification scheme and compared to corresponding 500-hPa GFS analyses. Cutoff lows are generally underrepresented in forecasts compared to verifying analyses, particularly over continental midlatitude regions. Moreover, features identified in short- and medium-range forecasts are generally associated with easterly zonal position errors over the conterminous United States and northern Eurasia, particularly during the spring, consistent with subjective impressions of synoptic progressiveness. Further research is planned to identify conditions under which cases of synoptic progressiveness occur and to examine potential deficiencies in model physics, which may influence these errors.

GAZPACHO Version 6: A Summary of New Features and Enhancements

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This presentation will detail the changes and upgrades associated with the latest version of GAZPACHO (Gridded Automated Zonal and Complete High-Resolution Output) version 6 released in January 2022. The main changes were to add National Model Blend (NBM) percentile and deterministic forecast verification, localized county/state plot alternatives for Weather Forecast Offices (WFOs), plotting maximum winds from observations (combined with Real-Time-Mesoscale-Analysis data), and automatically creating analysis plots with a combination of various labels. A few examples will be shown to compare the output of the NBM verification for three different snow events (17-18 January 2022, 25 February 2022, 09 March 2022) that affected the Albany, NY WFO county warning area this past winter.

Improvement in NOAA Winter Weather Operations using New York State Mesonet Observations

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The primary goal of this project is to develop, evaluate and make available to NOAA innovative, high-quality winter weather data and products at high spatial and temporal resolution in real-time using NYSM operational data. Realtime products include snow depth, snowfall rates and accumulation, snow water equivalent, total liquid equivalent precipitation, snow to liquid ratio, precipitation type, camera images and frozen soil at 126 NYSM stations and are updated every 5 minutes. Innovative algorithms were developed to determine the precipitation type using the data from both NYSM standard and profiler networks. The winter weather products are evaluated against independent measurements and by operational partners. A winter weather website (http://nysmesonet.org/weather/winter) was developed to display real-time and archived products to aid data interrogation and inform warning operations and decision making. The ultimate goal is to permanently transition these data and products into regular, real-time operations by NWS WFOs and RFCs. The primary benefit of this project is to yield accurate ground truth observations for improved winter weather operations. This project provides an accurate historical dataset (5+ years) as well as ongoing real-time weather observations, to be used for research (model and satellite validations) and operations (emergency management, road weather, utilities). This presentation will focus on giving an overview of the project, showing some preliminary results on elevation-dependent snowfall estimates and seeking inputs from WFOs on improved and new products and features.

Data Fusion: A Machine Learning Tool for Forecasting Winter Mixed Precipitation Events

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Operational forecasters face a plethora of challenges when making a forecast; they must consider a multitude of data sources ranging from radar and satellites, to surface and upper air observations, to numerical weather prediction output. Forecasts must be done in a limited window of time, which adds an additional layer of difficulty to the task. These challenges are exacerbated by winter mixed precipitation events where slight differences in thermodynamic profiles or changes in terrain create different precipitation types across small areas. In addition to being difficult to forecast, mixed precipitation events can have large-scale impacts on our society.

To aid forecasts being made for these events, the goal of this project is to take the multiple data sources used by forecasters and combine them together using machine learning to improve forecasting ability for mixed precipitation events. The anticipation is that by employing a machine learning framework, forecasters will have more time to spend analyzing the most difficult portions of the forecast.

In order to achieve these goals, Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) daily observations from trained reporters between January 2017 to September 2020 were used to identify precipitation events that included rain, snow, freezing rain, and sleet. The data associated with the timing of these mixed precipitation events were collected from the New York State Mesonet, National Weather Service upper air soundings, High-Resolution Rapid Refresh model (HRRR), and North American Mesoscale forecast model with a nested domain (NAMNEST).

A random forest machine learning algorithm was trained and tested on the identified cases from the CoCoRaHS reports. This algorithm went through internal testing on the CoCoRaHS dataset, and that testing showed that rain and snow can be accurately forecast with accuracy scores around 86% and 90% respectively; sleet and freezing rain can be forecast with moderate accuracy with accuracy scores around 51% and 66% respectively. It is worth noting that the accuracy score of some mixed precipitation occurring was on par with rain and snow at around 85%.

An operational website was developed to display the products made with the output of the random forest algorithm. The products created to run the nowcasts and forecasts will be tested in previous events as well as predicting new events. The website was operational in real-time during the 2021-2022 winter season. The algorithm was also run to create the same products for the 2020-2021 winter season; this was done to increase the sample size of products to do verification on. Verification was completed by using ASOS and MPING observations as ground truth. Early results from the verification process give a positive indication that certain products can provide accurate precipitation type forecasts to be employed in combination with analysis by an operational forecaster.

Update on Research to Operations Activities: Some Successes and New Challenges

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Stony Brook University has had a few NOAA CSTAR projects during the past decade focusing on better use of ensembles in operations. This collaboration focused mainly on the development on operational web pages at the university for ensemble sensitivity and clustering using the GEFS, ECMWF, and CMC ensembles (100 members out several days). Much was learned about how to apply these tools to operations given the collaborative feedback, but these tools were still not in the NWS offices and thus not used on a regular basis. Thanks to some resent Joint Technological Transfer Initiative (JTTI) funding and collaboration with the Weather Prediction Center (WPC), the ensemble clustering tool is now operational and available to more than 40 NWS offices using the Dynamic Ensemble-based Scenarios for IDSS (DESI) software. Clusters are generated using a K-means approach and the two leading Principal Components (PCs) for the 500 hPa height for several regions around CONUS. Other cluster fields are derived from these 500 hPa clusters, and forecasters can plot 2-D spatial plots, meteograms, plumes, and various statistical quantities (percentiles, maximum, minimum, interquartile ranges, and differences from the multi-model mean). This talk will highlight some of the DESI capabilities, some recent survey results, as well as describe as new JTTI project that will make the Ensemble Sensitivity Tool more operational.

Stony Brook has a new CSTAR project "Improving Communication With Highly Vulnerable Societal Groups Through Partnerships, Audience Analysis, Crowd-Sourced Information, and Workshops." As tropical storm Ida illustrated in New York City in early September 2021 and more recently with hurricane Ian in Florida there are large challenges in hazard communication such that stakeholders take appropriate actions. This project is collaborating with NWS, NYC Emergency Managers, community leaders, Creare LLC, and others to connect with Highly Vulnerable Societal Groups (HVSGs). We will initiate community listening through focus groups and interviews and learn from HVSG community members about the challenges they encounter in taking protective action in the face of weather hazards. We will present the goals and upcoming plans for this CSTAR as well as a related online workshop Stony Brook led last year involving ~160 college students around the country last year using a fictitious campus and landfalling hurricane to test some hypotheses involving visualization and how people interact with each other to help make decisions.

Using Machine Learning Clustering Algorithms to Identify Synoptic Environments Conducive to Flood/Flash Flood Conditions in the NWS Boston (BOX) County Warning Area

Rob Megnia
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NWS Boston implemented a K-Means clustering algorithm, a form of Machine Learning, to identify groupings of synoptic height patterns associated with non-tropical flood/flash flood environments in the BOX county warning area. This type of analysis allows the computer to take large samples of ensemble forecast members and break down that data into K-solutions, where the numerical value of K is the number of clusters. This enables forecasters to narrow down their focus onto fewer, but often more general, solutions or scenarios. In this study, the K-Means clustering algorithm was used to identify four synoptic height patterns commonly associated with non-tropical flood/flash flood environments. Local Storm Reports (LSRs) for flooding and flash flooding since 2008 were gathered to identify dates in which flooding/flash flooding occurred. All LSRs associated with tropical systems were removed, since the primary goal of this study was to identify mid-latitude synoptic height patterns associated with flood/flash flood environments. Additionally, LSRs were combined into "events" so that each synoptic height field used in the cluster analysis was unique.

Once all event dates were determined, the K-Means clustering algorithm was applied to North American Regional Reanalysis (NARR) 500 hPa geopotential height field data associated with each event. The height fields were clustered into four separate groups. Once the four groups were determined, composites for each group were generated for the following fields:

- 250 hPa heights/winds
- 850 hPa heights/winds
- 700 hPa heights/IVT/2m dewpoint
- MSLP/1000 hPa winds/ SB CAPE

After analyzing the composites in each of the four clusters, it was found that each of the four environments were unique with respect to synoptic forcing, instability, wind fields, and storm motion. Further mesoscale analysis was applied by sampling NARR data from each cluster member at the grid point nearest to the respective LSR. The 2-m dewpoint, SBCAPE, storm velocity, storm-motion direction, soil moisture, and precipitable water were considered in the mesoscale analysis. Storm velocity, soil moisture, and CAPE varied the most from cluster to cluster. Conclusions made from this study were that synoptic and mesoscale environments associated with flood/flash flood environments in the BOX CWA rely on a delicate balance of instability, storm motion, and synoptic forcing. Flood/flash flood environments can appear in varieties of height patterns, so long as the aforementioned parameters are balanced favorably. This study also served as an example of how cluster analysis can be used to enhance composite analysis for unique weather events.

Analysis of the 15 May 2018 Severe Weather Event in Eastern New York

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A widespread severe weather outbreak took place on 15 May 2018 across portions of the Northeast. Impacts in New York were significant and occurred in two phases. The first phase consisted of several supercells across the Mid-Hudson Valley. These storms produced damaging winds, very large hail (> 4.5cm), and several tornadoes. The second phase, which occurred later in the afternoon, featured a more linear storm mode. This line of thunderstorms produced widespread wind damage across the southern Hudson Valley into New York City.

Synoptic and mesoscale ingredients began to fall into place prior to the event. At 12:00 UTC on 15 May 2018, a southwesterly jet streak was located over southern Quebec. At the surface, beneath the equatorward entrance region of this jet streak was an elongated region of low pressure along the US/Canada border. Throughout the day, this low-pressure system deepened and moved into the Northeast. Southerly surface flow in the warm sector of the approaching low-pressure system advected warm, moist air into the Northeast. During the morning of 15 May 2018, a line of storms moved across the southern tier of New York.

Convection allowing models (CAMs) handled this morning convection poorly. Most CAMs simulated morning convection dissipating before reaching eastern New York. The storms instead maintained their intensity, crossing into Massachusetts around 15:30 UTC. The remnant cold pool and associated boundary from these storms were critical in initiating the supercell thunderstorms in the first phase of the event. While these CAMs successfully forecasted the linear mode in the late afternoon, they largely failed to capture the supercell threat during the first phase of the event. This research study investigates the mesoscale evolution of the severe weather outbreak and the reasons for poor CAMs performance.

Precipitation Type in the High-Resolution Ensemble Forecast System during the February 17th & February 23rd, 2022 Winter Storms

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Winter weather events with near-freezing surface temperatures are often associated with mixed surface precipitation types (p-types) and are shaped by synoptic, mesoscale, and microscale processes. The Winter Precipitation Type Research Multi-Scale Experiment (WINTRE-MIX) focuses on how these processes influence the variability and predictability of p-type and amount under near-freezing surface conditions. Accurately predicting p-type in these conditions is a forecast challenge. The High-Resolution Ensemble Forecast (HREF) system outputs ensemble products from a collection of mesoscale models, assisting forecasters in probabilistic forecasting. Included in the forecast ensemble are four configurations of the Weather Research and Forecasting (WRF) model, and a Finite Volume Cubed Sphere (FV3) model. Each member of the forecast ensemble is diverse with respect to the dynamical core, physics parameterizations, and initial/boundary conditions.

This study will investigate near-freezing precipitation from two winter storms to evaluate commonalities and discrepancies between members of the HREF ensemble and to explore what meteorological features contribute to member discrepancies. HREF member output will be compared to observations from the New York State Mesonet (NYSM), Automated Surface Observing System (ASOS), CFI Climate Sentinels, and meteorological Phenomena Identification Near the Ground (mPING). Additional observations include radiosondes and manual surface observations from the WINTRE-MIX campaign. The February 17th & 18th winter storm was associated with an elongated NE-SW frontal boundary with a surge of northerly, terrain-channeled cold air into the Champlain Valley leading to an extended period of freezing rain and ice pellets. The complex terrain of the Champlain Valley and the timing of the frontal passage complicated this forecast and led to a diverse output between members. The February 22nd & 23rd winter storm was associated with a swath of freezing rain moving along the St. Lawrence River from the southwest, this storm was additionally difficult to forecast due to a shallow, below-freezing, surface cold layer which yielded to be a significant challenge for the HREF members to forecast.

Validation of Offshore Winds in the ERA5 Reanalysis Using Two Floating LIDARS South of Long Island

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Wind forecasting over the coastal waters is challenging given the lack of observations and the limitations the operational models have in predicting the marine boundary layer. One particular warm season coastal wind phenomenon is the southerly low-level jet (LLJ), since it impacts rip currents, marine interests, aviation, etc. These jets and offshore wind prediction is also important for the renewable wind industry, which has required the use of assumed boundary layer wind profiles (i.e., log-law and power-law), mesoscale models, and model reanalyses. Thus, more understanding of ambient atmospheric conditions that lead to model reanalysis wind speed biases is needed. Using approximately two and a half years (4 September 2019 - 31 January 2022) of hourly vertical wind profiler data from two New York State Energy Research and Development Authority (NYSERDA) floating lidars in the New York Bight and ERA5 Reanalysis, this study aims to understand how well the reanalysis wind speed profiles compare against observations in in the lowest 200 m ASL and for LLJ events. The ERA5 had 8 sigma levels in the lowest 200 m to do the validation, while the lidar data was every 20 m in the vertical. To explore the LLJs, we identified warm season (May-September) LLJ events using the observed floating lidar wind profiles and a modified detection algorithm from Debnath et al. (2021). The algorithm detected 289 hours that had a wind speed maximum between 40-180m ASL and that satisfied the below jet nose shear threshold of the 90^{th} percentile value of the 40-160m speed shear and the criteria of a wind speed drop-off above the jet of greater than or equal to 1.5 ms^{-1} and 10%. These 289 LLJ hours are equivalent to 91 days having at least one detected LLJ hour.

We found that ERA5 reanalysis tends to underpredict the wind speeds by 0.32% – 8.7% through the 200m profile during spring and summer months. The spring months and June have the largest negative ERA5-lidar wind speed biases of 1.0 - 2.0 ms^{-1}, with a clear diurnal trend in this reanalysis bias. The wind underprediction in May and June from 2200 - 0300 UTC coincides with the months having the highest frequency of LLJ events. During these LLJ periods, the ERA5 had 72 hours (or 24.9%) that did not have a LLJ profile. On the average, the lidar observed LLJ profile had a jet nose maximum of 10.85 ± 0.35 ms^{-1} at 100m ASL, while the corresponding ERA5 average profile had a weaker, smeared out, and elevated nose of 9.0 ± 0.33 ms^{-1} at 140-160 m. Comparisons of the average observed lidar and ERA5 LLJ profiles reveal the largest negative wind speed biases of 2.0 - 2.20 ms^{-1} at 80 m ASL, which closely corresponds with the May and June 2200 - 0300 UTC values of mean wind speed bias. Given this initial comparison, ERA5 reanalysis should be used with caution for U.S. East Coast offshore wind prediction, and a bias correction algorithm needs to be developed.

Analysis of the 14 December 2018 Severe Weather Observed During RELAMPAGO

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Argentina, specifically the Córdoba region, is home to some of the most unique severe storms in the world. Rapid upscale growth from discrete convection to intense lines is one of the more distinguishing features of these storms. The South American Low-Level Jet (SALLJ) acts as a moisture transport mechanism, siphoning moist air from the Amazon Rainforest into the mid-latitudes of the continent. The SALLJ can be particularly strong when lee cyclogenesis takes place downstream of the Andes Mountains resulting from the passage of an upper-level trough. Specific to the Córdoba region are the Sierras de Córdoba (SDC), a mountain range much smaller than the towering Andes, yet a complicating factor in convective initiation, growth, and sustenance. Combining ample moisture with vertical shear associated with the SALLJ, high instability, and complex terrain, the region around the SDC is prone to impactful severe weather. The range of convective modes, shifting from discrete to linear, allow for the various hazards of large hail, high winds, flooding rain, and the occasional tornado in this region of the world.

This case study seeks to point out the major factors, both synoptic and mesoscale, of the 14 December 2018 severe weather and upscale growth case. Three 500-hPa troughs crossed the Andes in quick succession, setting up an uninterrupted period of northerly flow at low-levels into central Argentina. The final trough was located just upstream of the Andes at 1200 UTC on 13 December. It was the strongest trough, and as such, resulted in the severe weather. On 13 December, convective cells initiated in the afternoon, moving from the northeast to the southwest. These moved southwest as convective initiation continued in the same region. Cells began to build to the northwest over the higher terrain of the SDC, propagating towards the northeast as a cold front associated with the surface cyclone moved in that direction. Upscale growth into one large mesoscale convective system (MCS) was evident into the early morning of 14 December. In addition, there were several instances of backbuilding convection over the terrain. Further work will be done to explore the role of the terrain in the backbuilding of convection.

September 5, 2022 Flash Flooding in Providence, RI

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On September 5, 2022 six to nine inches of rain fell in a short period of time in northern Rhode Island which resulted in considerable flash flooding around the greater Providence area. Many roadways were inundated by flooding, including Interstate 95 which was shut down in both directions.

A stalled frontal boundary over Rhode Island provided the showers and thunderstorms a favorable environment for warm rain processes (a deep saturated above-freezing layer up to 15,000 feet AGL on the edge of the instability gradient). High-resolution model guidance, including the SPC HREF, performed very well by highlighting the affected area nearly 18 hours in advance. This allowed for effective messaging to core partners and led to high situational awareness as the event began to unfold. Flash Flood Warnings were issued with a preliminary average lead time of 35 minutes.

This presentation will review the synoptic and mesoscale environments associated with this event. Select guidance from the SPC HREF that were used in the forecast process, to message and collaborate, as part of the Weather Prediction Center Collaborative Forecast will be presented. Additionally, radar data, including MRMS analyses, will be reviewed in order to show the evolution of this event.

Using MRMS Rotational Tracks for Northeastern US Tornado Warning Guidance

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Although tornadoes are infrequent compared to central and southern parts of the country, tornadoes do occur within severe thunderstorms across the northeastern parts of the United States. Since 2017, 31 tornadic events have occurred within the National Weather Service Albany New York County Warning Area (CWA). Forecasters at the Albany Weather Forecast Office have traditionally used the V-R Shear relationship as a part of the warning process. The V-R Shear relationship is a linear relationship between gate-to-gate shear and rotational velocity, which was locally updated in 2012 to account for the upgraded radar data to 8 bit resolution. Assessing the mid-level rotation through this method can be time consuming, as the warning meteorologist will need to look at either a vertical cross-section or multiple plan view images at different radar elevation slices to assess the strength of the mid-level rotation.

As a result, more tools and strategies are needed to help meteorologists to quickly evaluate storm-scale rotation. MRMS rotational tracks can be a useful tool during the tornado warning process. The Radar Application Course (RAC) teaches that both low and mid-level rotation tracks from the MRMS can be useful for a warning meteorologist to examine, as they show the maximum azimuthal shear within different layers. With data arriving from more than one radar site, these rotation tracks have the benefit of eliminating some of issues with beam blockage and beam widening that occur when using just a single radar site.

Considering this, MRMS rotation tracks were examined for the 31 tornadoes that occurred in the Albany CWA since 2017 and for the 24 events that tornado warnings were issued where no tornadoes were reported. The highest values around and just before the tornado event (or warning issuance) were recorded. As seen in the results of the V-R Shear study, values of low level and mid-level rotational shear are similar for both the tornadic and non-tornadic events. With a limited sample size and all tornadic events being on the weaker side (all EF0s and EF1s), it is possible that a stronger signal may be seen in time with a larger and more robust database.

Improvement of Tornado Detection and Lead Time: Update of Environmental and Radar Parameters for the WFO Boston/Norton County Warning Area

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The twenty seven tornadoes that occurred in the WFO Boston/Norton (BOX) County Warning Area between 2018 and 2021 were analyzed to update the previous work by Brooks et al. (2008) and O'Brien et al. (2017) which reviewed tornado environments and radar signatures as part of a CSTAR VII Collaborative Project.

The updated study confirmed previous environmental and radar findings. Tornadoes were most often associated with the presence of a closed 500 hPa low near southern Ontario in low CAPE and high shear environments along with tropical moisture and the presence of a low level boundary to induce spin-up. Results were also stratified by synoptic classification to determine if there were any significant differences among varying environments. Thresholds for the Radar Warning Guide were also examined and were validated based upon the more recent events.

This presentation will give a brief overview of the previous studies' work and will focus on the results of the updated study.

November 13, 2021 Southern New England Tornado Outbreak

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A highly unusual late-season tornado outbreak occurred in the Northeastern United States on November 13, 2021. A total of 11 tornadoes (9 EF-0 and 2 EF-1) touched down in Connecticut, Rhode Island, and on Long Island, New York. These were the first November tornadoes on record reported in Connecticut and Rhode Island going back to 1950. In addition, all the tornadoes occurred near the immediate coastline, likely a result of sea surface temperature anomalies that were 2C to 4C greater than normal for that time of year.

In this presentation, we examine the meteorology behind this highly unusual November Quasi-Linear Convective System (QLCS) tornado outbreak. Both the upper level and surface features will be reviewed in this presentation. This will cover how the formation of a subtle triple point low pressure system can increase the risk for tornado formation. This event also showed that 0-3 km CAPE and 0-1 km shear were critical factors in tornadogenesis which is typical for late season events. Therefore, awareness of the mesoscale environment is critical for anticipating these types of severe weather events and ensuring successful warning operations. A WRF model hindcast will also be shown to examine the impact of higher sea surface temperatures on storm coverage and intensity.

The January 28-29, 2022 Mid Atlantic Blizzard

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On January 28-29, 2022 an explosively deepening storm system tracked northward over the western Atlantic impacting much of the east coast including the mid-Atlantic region with heavy snowfall and blizzard conditions. Within the NWS Mount Holly/Philadelphia (PHI) forecast area, impacts included upwards of 20 inches of snow along the coast of New Jersey (NJ) along with winds gusting over 60 mph resulting in blizzard conditions occurring in several counties. Farther west, 5 to 8 inches of snow fell across the urban corridor from Philadelphia to Trenton.

This storm was noted by the difficulty numerical weather models had in accurately forecasting the low's track and impacts, particularly QPF and snow amounts. Similar to many strong, dynamic east coast storm systems, there was a general trend north and westward in the model's forecast track as the event drew closer in time. However within this general trend there were notable forecast jumps, and this presented some messaging challenges for the storm. For example, many of the 12z model runs on Jan 26, 2022 shifted the storm's forecast track *eastward.* This was largely driven by the GFS and its ensemble members which, upon close inspection, appeared to be under-dispersive, relative to ensemble members from the ECMWF and GEM. This resulted in the operational version (v4) of the National Blend of Models (NBM) shifting the axis of heaviest snowfall eastward which would prove not to be the correct solution, and thus significantly lowering deterministic forecast snow amounts in the PHI forecast area. However, the NBM snowfall probability distribution was more muted with this eastward shift of the snowfall threat. PHI forecasters were able to correctly diagnose that the GFS/GEFS represented an outlier scenario, and maintained or even *increased* forecast snow amounts with the Jan 26 PM forecast update. This situational awareness resulted in more consistent messaging of the snowfall threat that proved to be accurate, especially given the changing model forecasts. This led to excellent warning verification and more effective IDSS.

This study examines the forecast process PHI forecasters used to correctly improve on the model consensus snowfall forecasts. Leading up to this storm, forecasters critically examined model forecast surface patterns and with the forecast forcing features aloft to assess potential storm evolution scenarios. This case highlights the important role of the human forecasters to provide expert diagnosis and interpretation of model output and effectively communicate the potential for hazardous weather. Forecasters were able to recognize that a subset of models, were depicting an unlikely scenario that was causing the NBM v4.0 deterministic snowfall forecasts to waffle back and forth between Winter Storm Warning criteria to almost nothing for places like Philadelphia along the I-95 urban corridor. PHI was able to message consistent snowfall forecasts that proved to be accurate, thereby providing valuable information for decision making.

Forecast and Impact-Based Decision Support Services During the January 28-29, 2022 Blizzard in Southern New England

Rodney Chai and Hayden Frank
NOAA/NWS/WFO Boston/Norton, Massachusetts

The January 28-29, 2022 blizzard was one of the most impactful winter storms for southern New England in recent years. Boston, Massachusetts, tied the all-time record for daily snowfall with 23.6 inches, and Providence, Rhode Island, broke the all-time record for daily snowfall with 18.8 inches. Snowfall rates were as high as 2 to 4 inches per hour; this created nearly impossible travel conditions with the near-hurricane force wind gusts. The heavy, wet snow that fell on Cape Cod and the Islands resulted in hundreds of thousands of power outages.

This presentation will describe the challenges associated with forecasting and messaging this storm. The importance of mesoscale analysis, including the integration of high-resolution data, will be highlighted to show how meteorologists at the National Weather Service (NWS) in Boston were able to integrate this information into the warning decision making process. As a result, NWS Boston provided highly effective briefings to core partners by providing detailed information, such as hourly snowfall rates and timing of blizzard conditions. This allowed partners at the Massachusetts Emergency Management Agency, MassPort (which operates Logan Airport), and other agencies to make more informed decisions when deploying their resources in advance of the storm. The office also harnessed the power of social media leading up to this very impactful storm, reaching over two million users on Meta (i.e., Facebook) and 7.8 million users on Twitter.

The Heavy Mixed Precipitation and Localized Ice Storm on 3-4 February 2022 in Eastern New York
Part I: Synoptic and Mesoscale Overview

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A heavy mixed precipitation and localized ice storm occurred on 3-4 February 2022 across eastern New York (NY) and western New England in the National Weather Service (NWS) Albany New York County Warning Area. A prolonged and significant precipitation event occurred across eastern NY and western New England with one to two and a half inches of liquid equivalent falling. Rain quickly transitioned on 3 February 2022 to a variety of wintry precipitation types as an anafront moved southward across the region from late afternoon into the early evening. Heavy snow (8 – 16 inches) occurred north and west of the Capital Region over the Mohawk Valley, southern Adirondacks and the Lake George Area. Heavy accumulating sleet (up to and in excess of 2 inches), and lighter snow accumulation occurred in the Greater Capital Region. A localized yet significant ice storm occurred over portions of the Mid-Hudson Valley in eastern NY. The spatial distribution of ice accretion and associated significant societal impacts were modulated by the complex terrain and were extremely variable. Most of the freezing rain impacts were minor, except across portions of central and eastern Ulster County where heavy localized ice accretions (0.50-0.75 inches of flat ice) caused 46,000 customers, or roughly half of the customers in the county, to lose power. Such a complex winter event presented numerous challenges to NWS forecasters as they communicated hazards and impacts to New York and western New England federal, state and county partners.

The first part of this case study presentation will focus on a synoptic and mesoscale overview of the event with an additional focus on the observations. Analysis of radar data compared to observations and forecasts from the HRRR and HREF will be briefly shown. Low-level moisture and wind anomalies ahead of the positively-tilted 500 hPa trough will be reviewed from the North American Ensemble Forecast System. The role of mid and upper-level jet streaks and low and mid-level 2-D Petterssen frontogenesis will be discussed in the enhancement of the heavy mixed precipitation 00 UTC to 12 UTC 4 February. Colder sub-freezing air would push southward from northwest to southeast from the Mohawk Valley and southern Adirondacks into the Greater Capital Region and Mid-Hudson Valley across eastern NY overnight with snow, sleet and freezing rain becoming the predominant precipitation types as multiple waves moved along the cold front. The 00 UTC 4 February 2022 KALB sounding showed the evolution of precipitation types from rain/freezing rain with a shallow warm nose to a classic sleet sounding with a deep cold-air wedge in the lowest part of the boundary layer (surface to 3.3 kft) with a warm nose aloft at 12 UTC 4 February 2022. An observational sounding analysis will be reviewed. The NYS mesonet also enhanced situational awareness as the event unfolded providing 5-minute temperature, precipitation rate and amounts, wind speeds, and hourly web cam images.

The Heavy Mixed Precipitation and Localized Ice Storm on 3-4 February 2022 in Eastern New York
Part II: Warnings, Communication of Hazards and Verification

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A heavy wintry mixed precipitation and localized ice storm occurred on 3-4 February 2022 across eastern New York State (NYS) and western New England in the National Weather Service (NWS) Albany New York County Warning Area. Heavy snow (8 – 16 inches) occurred north and west of the Capital Region over the Mohawk Valley, southern Adirondacks and the Lake George Area. Heavy accumulating sleet (up to and in excess of 2 inches) along with lighter snow amounts occurred in the Greater Capital Region. The spatial distribution of ice accretion and associated significant societal impacts were modulated by the complex terrain and were extremely variable. While most of the freezing rain impacts were minor, a localized yet significant ice storm occurred over portions of the Mid-Hudson Valley in eastern NYS. In portions of Ulster County, heavy ice accretions (0.50 – 0.75 inches of flat ice) resulted in power outages for roughly half of the county.

The second part of this case study highlights some of the challenges associated with communicating hazards and impacts of this storm to New York and western New England federal, state and community partners, as well as verification. Challenges included expressing uncertainty with the exact wintry precipitation amounts and transition zones (snow vs. sleet vs. freezing rain) as well as discussing the overall timeline and duration of the event. NWS Albany briefings to partners began on 30 January 2022 and continued twice daily through the event. Briefings provided deterministic snow/sleet and ice forecasts and 10th and 90th percentile probabilistic information for snow/sleet amounts. Probabilistic guidance is designed to provide partners with reasonable "high end" and "low end" scenarios to ensure they are properly prepared. We also annotate forecast graphics to highlight areas with the most uncertainty. NWS Albany accommodated our transportation partners request for daily briefings. Lastly, the Freezing Rain Accumulation Model (FRAM) provided some assistance in predicting flat ice amounts.

While verification statistics for the storm as a whole exceeded performance goals, our ice forecasts were underdone in the Mid-Hudson Valley where the most significant impacts occurred. Errors in the icing forecast were mainly due to uncertainty with respect to thermal profiles and timing of precipitation type changes during the heaviest precipitation. Due to the complicated evolution of precipitation types, the warning versus advisory decisions were not straightforward, even in hindsight. For future icing events, the NYS Mesonet data has proven useful for verification efforts as it can be used as input into the FRAM. The output has shown to be a realistic proxy for flat ice amounts in areas where trained spotter data are not available.

Identification of Cool Season Precipitation Structures Within the Cyclone Comma Head during the IMPACTS Field Campaign

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The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) is an ongoing field campaign operated by NASA to investigate the structure of mesoscale snowbands. While significant research has explored single (primary) bands in the cyclone comma head, the broader spectrum of precipitation structures has not been widely explored, as not all quasi-linear structures fit the current rigid categories of primary or multibands. It is important to have an automated precipitation band identification for research as well as for operational convective allowing models used by forecasters. An updated precipitation band climatology around the cyclone would also allow one to better understand the environmental conditions that favor the spectrum of precipitation structures within the comma head within the context of lifting mechanism, stability, moisture, and shear.

Previous approaches that use a background radar reflectivity threshold for a large region (e.g., Northeast U.S.) to objectively identify precipitation structures is problematic, since this approach tends to create many small fragmented objects instead of more coherent bands, or merges many similar reflectivity bands as one amorphous feature. This talk will highlight a new algorithm developed to identify precipitation structures over multiple scales, building on work done by Ganetis et al. (2018). The algorithm divides a stitched reflectivity domain into several smaller boxes and computes the upper sextile reflectivity in each box, rather than throughout the whole domain. Image processing techniques such as image morphology and watershed segmentation are also utilized to further separate regions of enhanced reflectivity into discrete objects. The algorithm has been applied to several winter storm cases sampled by the IMPACTS field campaign during the 2020 and 2022 deployments. Results will also be compared with methods to identify bands from past literature, showing the strengths and limitations of this new algorithm.

Multifrequency Radar Observations of Precipitation and Turbulent Structures within East Coast Winter Storms

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There are a myriad of mesoscale structures within United States East coast winter storms, including snowbands, generating cells, gravity waves, and coastal fronts. These phenomena have been fairly well studied using conventional radars and models. Beginning in 2017, the Stony Brook Radar Observatory (SBRO) at Stony Brook University and Brookhaven National Laboratory on Long Island, NY have operated a suite of sophisticated millimeter wavelength radars ideally suited to study these complex winter storms. SBRO has operated or is currently operating a vertically-pointing W-band (ROGER), a vertically-pointing K-band (MRR-Pro), the Ka-band Scanning Polarimetric Radar (KASPR), and a dual-polarization X-band phased array radar (SKYLER-1), and a second-generation dual-polarization X-band phased array radar (SKYLER-2) on a mobile radar truck.

One mesoscale feature often observed by the KASPR are horizontal layers of enhanced spectrum width (SWL), which are observed in PPI scans, RHI scans, and vertical profiles. These SWLs observed in the PPI and RHI scans are associated with regions of vertical wind shear and are observed in both stratiform precipitation and more turbulent nor'easters. It is hypothesized that they may enhance precipitation growth processes. They range in thickness from sub-100m to greater than 1km, with most SWLs too thin to be observed by NEXRAD. The SWL physical properties and microphysical implications are investigated to understand their role within these winter storms. Preliminary results from the PPI analysis reveal that there is an exponential relationship between the magnitude of vertical wind shear and SWL thickness, where strong vertical wind shear is more likely to occur with thin SWLs than thick SWLs. SWLs which are relatively thin (< 500 m) have a peak occurrence between 2-3 km ASL which likely indicate shear regions associated with frontal zones. Across-SWL differences in reflectivity and mean doppler velocity from KASPR vertical profiles are positively skewed, showing that thicker SWLs are found in the regions of the most ice crystal growth.

During the winters of 2020 & 2022 the SBRO played a major role in the ground support for the NASA Investigation of Microphysics and Precipitation for Atlantic-Coast Threatening Snowstorms (IMPACTS) Campaign. During the January 16-17, 2022 snowstorm that traversed the East Coast and dumped heavy snow in Central and Upstate NY, the SBU mobile truck was stationed in Elmira, NY. On January 17 SKYLER-2 sampled short-lived snowbands using 1-deg azimuthal and ⅓ elevation resolution every three minutes. This first of its kind dataset illustrates some of the complex structures and transience in these storms not captured by operational radars. For example, KASPR, SKYLER-1 and SKYLER-2 illustrate plumes of ice that fallout from aloft that are sometimes associated with transient snowbands.

The Winter Precipitation Type Multiscale Experiment (WINTRE-MIX): Overview and Initial Results

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Fundamental challenges remain in observing, diagnosing, simulating, and forecasting near-freezing precipitation types (p-types), particularly during transitions and within complex terrain. Motivated by these challenges, the field phase of the Winter Precipitation Type Research Multiscale Experiment (WINTRE-MIX) was conducted from 1 February – 15 March 2022 to better understand how multiscale processes influence the variability and predictability of p-type and amount under near-freezing surface conditions. WINTRE-MIX took place near the US / Canada border, in northern New York and southern Quebec, a region with plentiful near-freezing precipitation influenced by the terrain. During WINTRE-MIX, existing advanced mesonets in New York and Quebec were complemented by deployment of: (1) surface instruments, (2) the National Research Council Convair-580 research aircraft, (3) two University of Illinois mobile Doppler radars, and (4) teams collecting manual hydrometeor observations and radiosonde measurements. Eleven intensive observing periods were coordinated.

Analysis of WINTRE-MIX observations is illuminating how synoptic, mesoscale, and microscale processes combine to determine p-type and its predictability under near-freezing conditions. WINTRE-MIX research will contribute to improving nowcasts and forecasts of near-freezing precipitation through evaluation and refinement of observational diagnostics and numerical forecast models. Preliminary results will be presented from WINTRE-MIX intensive observing period 5 (IOP5), which took place on 22–23 February 2022 and included rain, freezing drizzle, freezing rain, ice pellets, and snow in the study domain. The initial analysis demonstrates the range of measurements collected and how they are being used to address WINTRE-MIX objectives. Synoptic scale lower-tropospheric warm air advection and mesoscale terrain-channeled sub-freezing flow in the Saint Lawrence Valley strongly influenced thermodynamic profiles and surface p-types. Operational mesoscale models struggled to forecast precipitation type accurately during IOP5, particularly in the southern St. Lawrence Valley, where low-level cold air was only a few hundred meters deep. Airborne, radar, and other WINTRE-MIX field observations are used to highlight the role of mesoscale and microscale processes in determining the observed variability of p-types in this event.

Investigating the Differences Between Members in the High-Resolution Rapid Refresh Ensemble (HRRRE) During the 23 February 2022 Winter Storm

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Probabilistic forecasting with high-resolution ensemble numerical weather prediction is used to help create more accurate and understandable forecasts. Using percentages and probabilities allows for more depth to a forecast and allows forecasters to be able to convey a clearer message of what exactly they are expecting. Ensembles are a set of forecast models that have either different initial conditions, boundary conditions and/or formulations. They are one way of creating probabilistic forecasts and can help in the understanding of the likelihood of a specific outcome. Forecasters use ensembles to analyze the range of possible outcomes and the likelihood of those outcomes that a weather system can present. The High Resolution Rapid Refresh Ensemble (HRRRE) is an experimental ensemble product that aims to represent the forecast uncertainty using the distribution of forecast outcomes from a nine-member ensemble based on the HRRR model. We examine the synoptic-scale sources of variability across this ensemble for a mixed precipitation event, where there is an increased emphasis on the uncertainty of precipitation type (p-type). Specifically, we focus on differences in key variables and p-type between the warmest and coldest HRRRE members. Here, the members are classified based on how warm or cold they were within the WINTRE-MIX domain.

The forecast for both the camps of the ensemble are compared to ground observations, specifically 2-meter temperature, precipitation type, precipitation amount, and wind from the New York State Mesonet, the Automated Surface Observation System, the meteorological Phenomena Identification Near Ground, from the Winter Precipitation Type Research Multi-Scale Experiment (WINTRE-MIX). We also compare to data from soundings launched for WINTRE-MIX at four different sites around the St. Lawrence River Valley that provide vertical profiles of the storm. The event examined occurred from 22–23 February 2022 in northern New York and Southern Quebec. This event produced widespread icing from Northern New York through the St. Lawrence River Valley. The ensemble as a whole produced a solution that was too warm and produced too little wintry precipitation. So far research supports the fact that the colder members were closer to reality at the surface within the WINTRE-MIX region due to this difference. The day leading up to the event showed key differences in orientation of the 500mb trough. Warmer members showed a more amplified 500-mb trough across the west coast, which led to a stronger southerly flow in the warm sector of the surface cyclone. This enhanced southerly flow increased the warm air advection and led to the warmer solution seen within the warmer camp.

Modeling Surface Precipitation Type Transition from Freezing Rain to Ice Pellets: A WINTRE-MIX Case Study

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Diverse surface precipitation types (p-types) during wintertime have broad impacts on human society, but accurately forecasting the transitions between p-types is challenging. To better understand how multi-scale processes influence the variability and predictability of p-types under near-freezing conditions, Winter Precipitation Type Research Multi-scale Experiment (WINTRE-MIX) was conducted from February to March 2022 in northern New York and southern Quebec.

This study focuses on a winter storm that occurred on 17-18th February 2022 during the WINTRE-MIX field campaign. The event was characterized by terrain channeled low-level northerly cold air into the Champlain Valley and warm air advection aloft, leading to an approximate 5-h period of freezing rain and/or ice pellets. In this study, we investigate the variability between different model configurations in simulating the transition from freezing rain to ice pellets in the Champlain Valley and explore the potential factors that influence the duration of ice pellets. Surface station observations, manual p-type reports, and research soundings are used to evaluate the model performance in p-type prediction and relevant meteorological conditions.

The control simulation is conducted by using the WRF V4.2.2 model with a 1-km resolution innermost domain centered over the WINTRE-MIX study region. An HRRR-like model configuration is used with the MYNN scheme as the planetary boundary layer (PBL) scheme. The control run generally captures the time evolution of surface temperature, wind speed, and the wind direction change of the terrain-channeled airflow in the Champlain Valley, resulting in a good prediction of the transition from rain to freezing rain. However, the simulation has significant biases in reproducing the transition from freezing rain to ice pellets. The underestimated duration of ice pellets in the simulation is improved by using the MYJ scheme as the PBL scheme. A colder subfreezing layer in the MYJ run leads to the initiation of more cloud ice and subsequent larger depositional growth, which favors the earlier occurrence of ice pellets near the surface. Increasing cloud ice number concentration via secondary ice production in the MYJ simulation further improves the performance in modeling the p-type transition. These preliminary results suggest that vertical mixing within the PBL and ice crystal number concentration in the subfreezing layer potentially play an important role in determining the transition from freezing rain to ice pellets and the associated ice-pellet duration in the simulation.

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